Climate Change, Fuels, and Wildfire

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Joint Fire Sciences
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14. ABSTRACT

Climate affects both fuel availability and flammability on multiple time scales, and the relative importance of availability versus flammability as limiting drivers of wildfire activity varies across ecosystem types. Climatic controls on fuel flammability during the peak fire season dominate in dense forests with characteristically infrequent, high severity fire, while the effects of antecedent moisture on the availability of fine surface fuels may also play a role in forests with more frequent, lower severity fire regimes. Changes in future temperatures and in precipitation amounts, form (rain versus snow) and timing can all potentially alter fuels, fire regimes, and emissions. We will describe the primary drivers of fire activity in very diverse ecosystems in California and the Northern Rockies, and summarize how climate change may affect these. In order to assess changes in wildfire and emissions, it is particularly important to use modeling methods that demonstrably capture extreme events, as well as to model at spatial resolutions that can capture topographic influences on temperature and precipitation. We demonstrate probabilistic statistical models that are designed to meet these requirements in California and Northern Rockies. We demonstrate methods that allow the estimate of fuels management on vulnerability to climate change in diverse ecosystems. Altered climate may drive changes in burned area and fire severity may in turn profoundly impact emissions from wildfire in some areas of the western US. We demonstrate the production of emissions scenarios for approximately 2000 future climate and development scenarios in California, and discuss the important drivers of differences in emissions across a wide range of scenarios.

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CLIMATE CHANGE, FUELS, AND WILDFIRE

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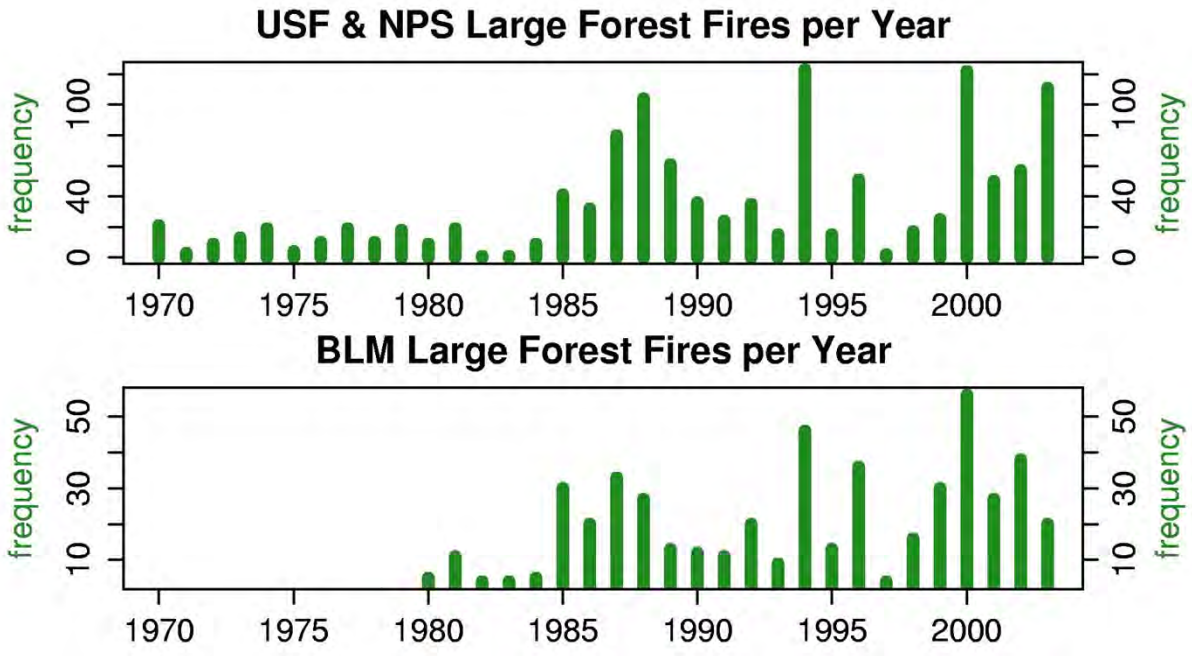
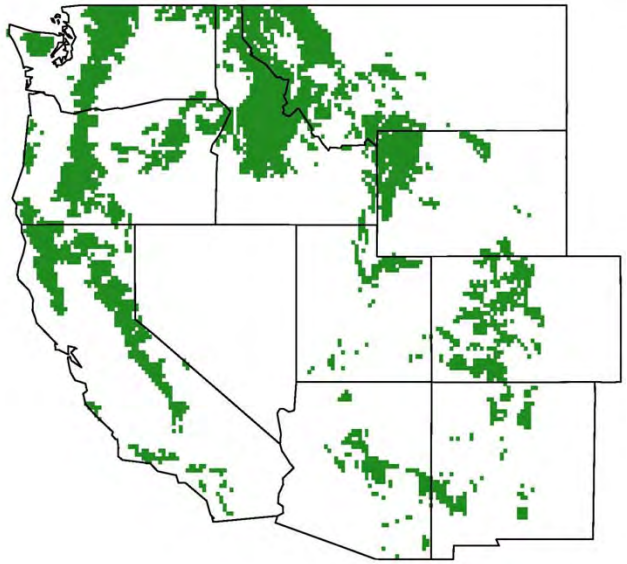
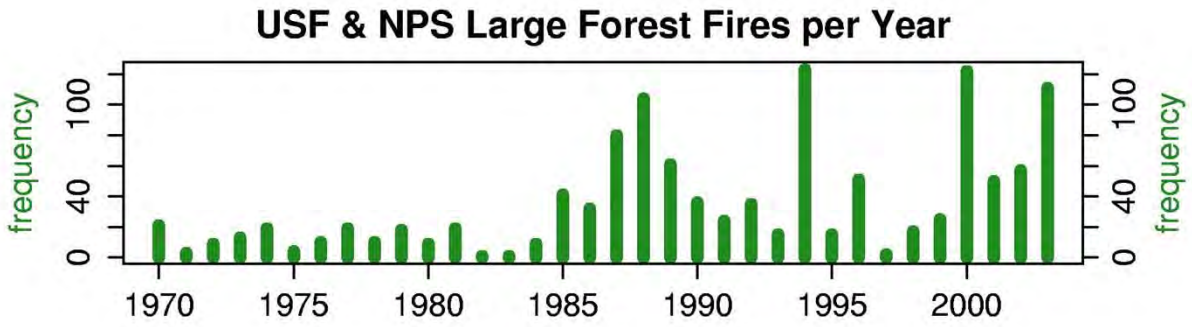
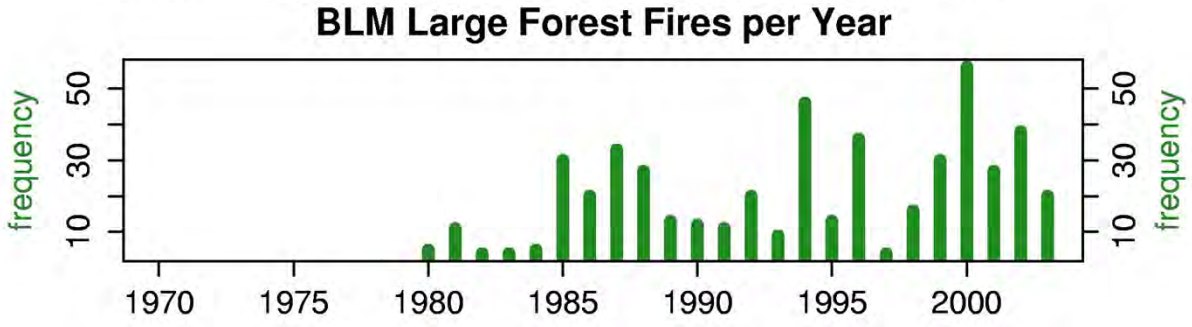


Since the mid-1980s

Large Forest Wildfires Have Increased ~300%



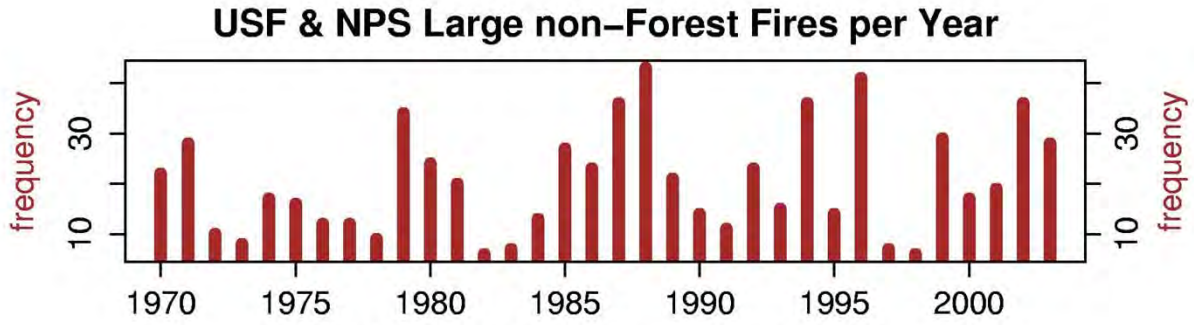


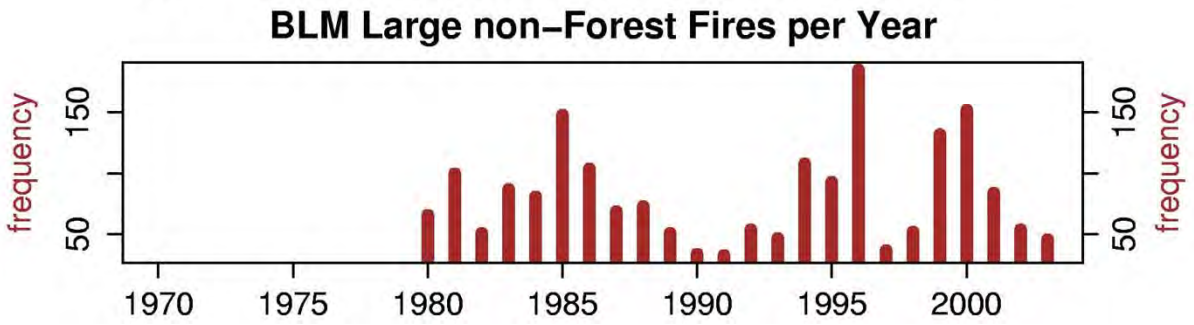


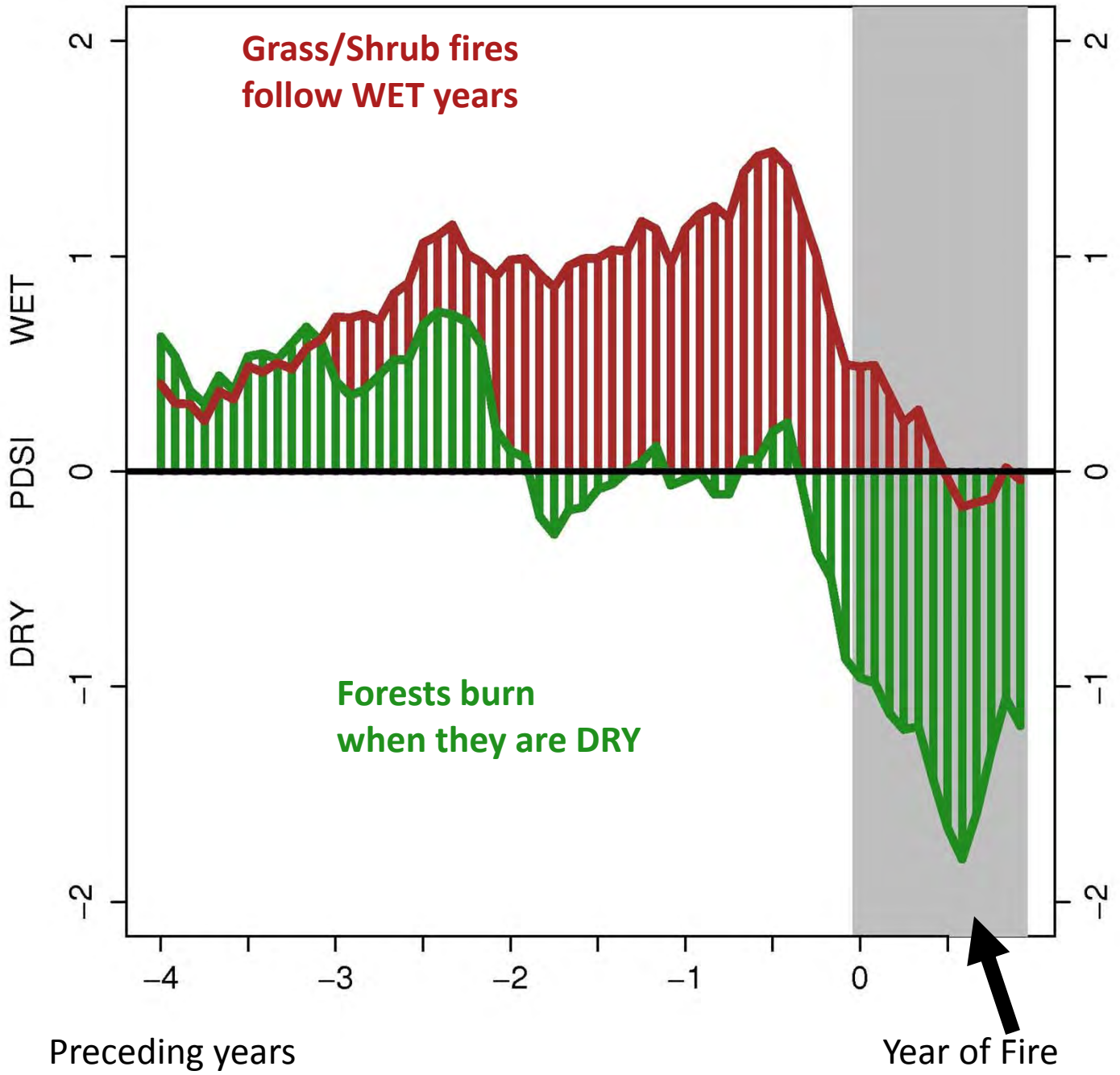
Since the mid-1980s

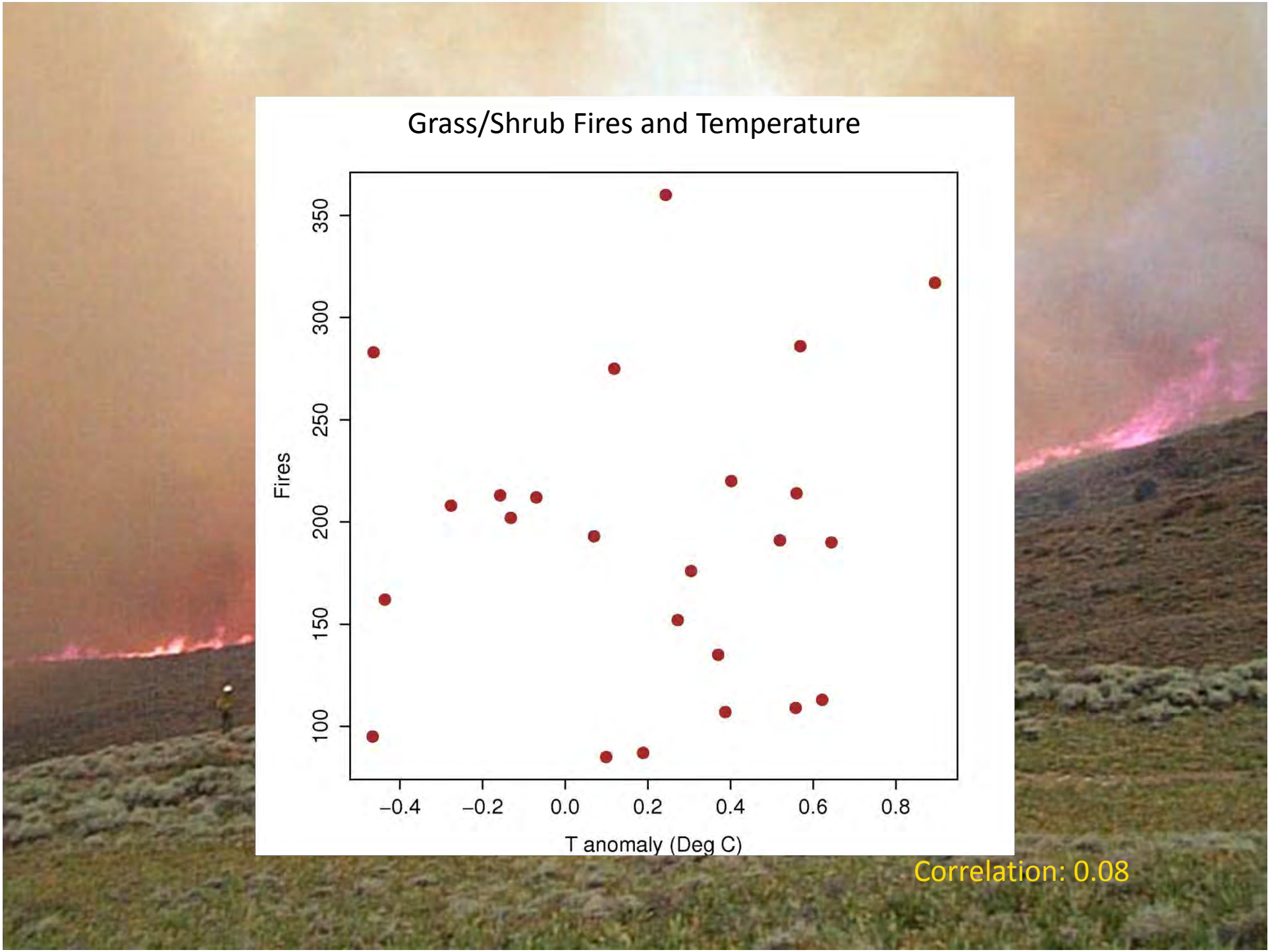
Large Forest Wildfires Have Increased ~300%

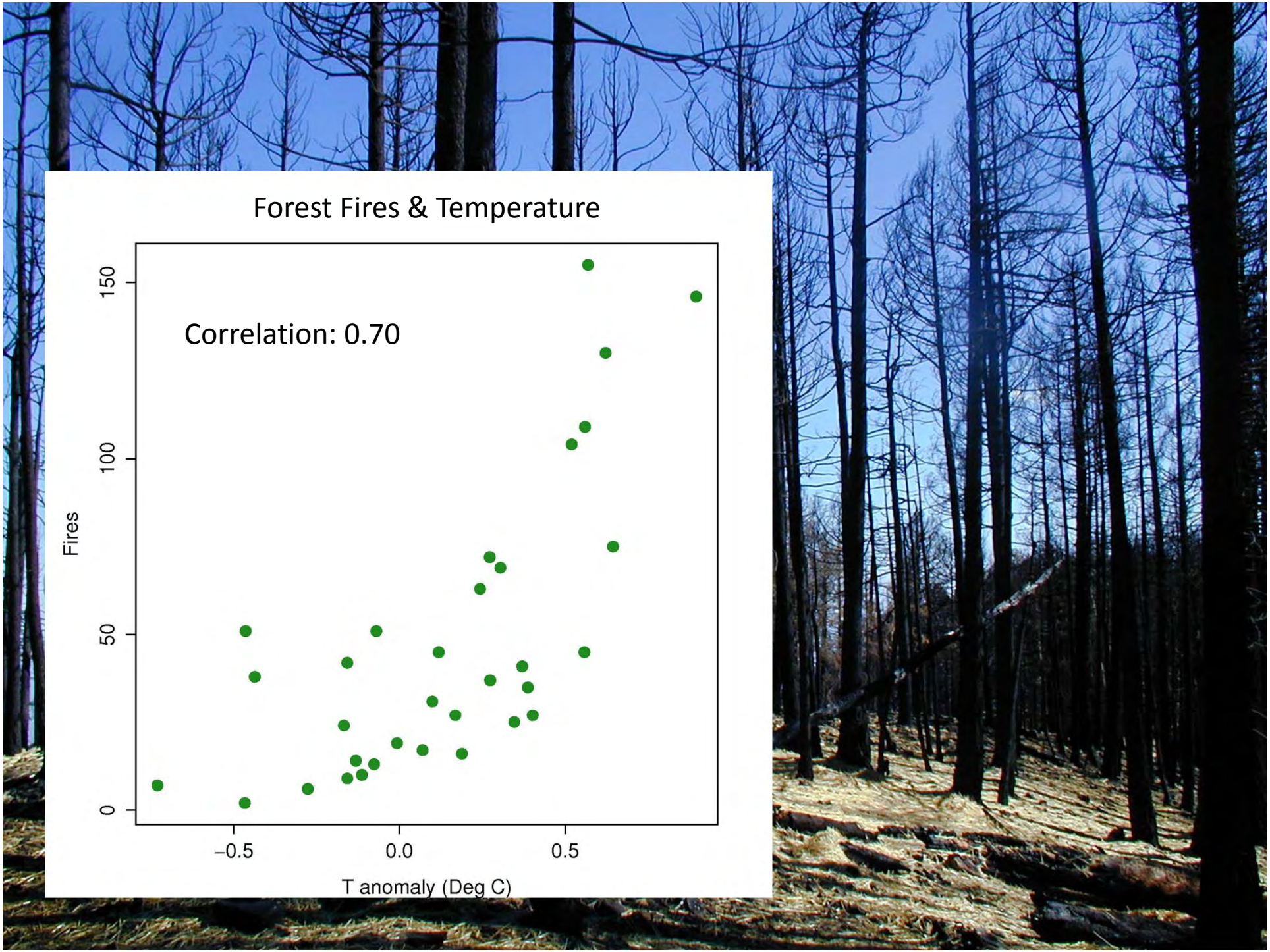
Other Large Wildfires Have Not Changed Substantially

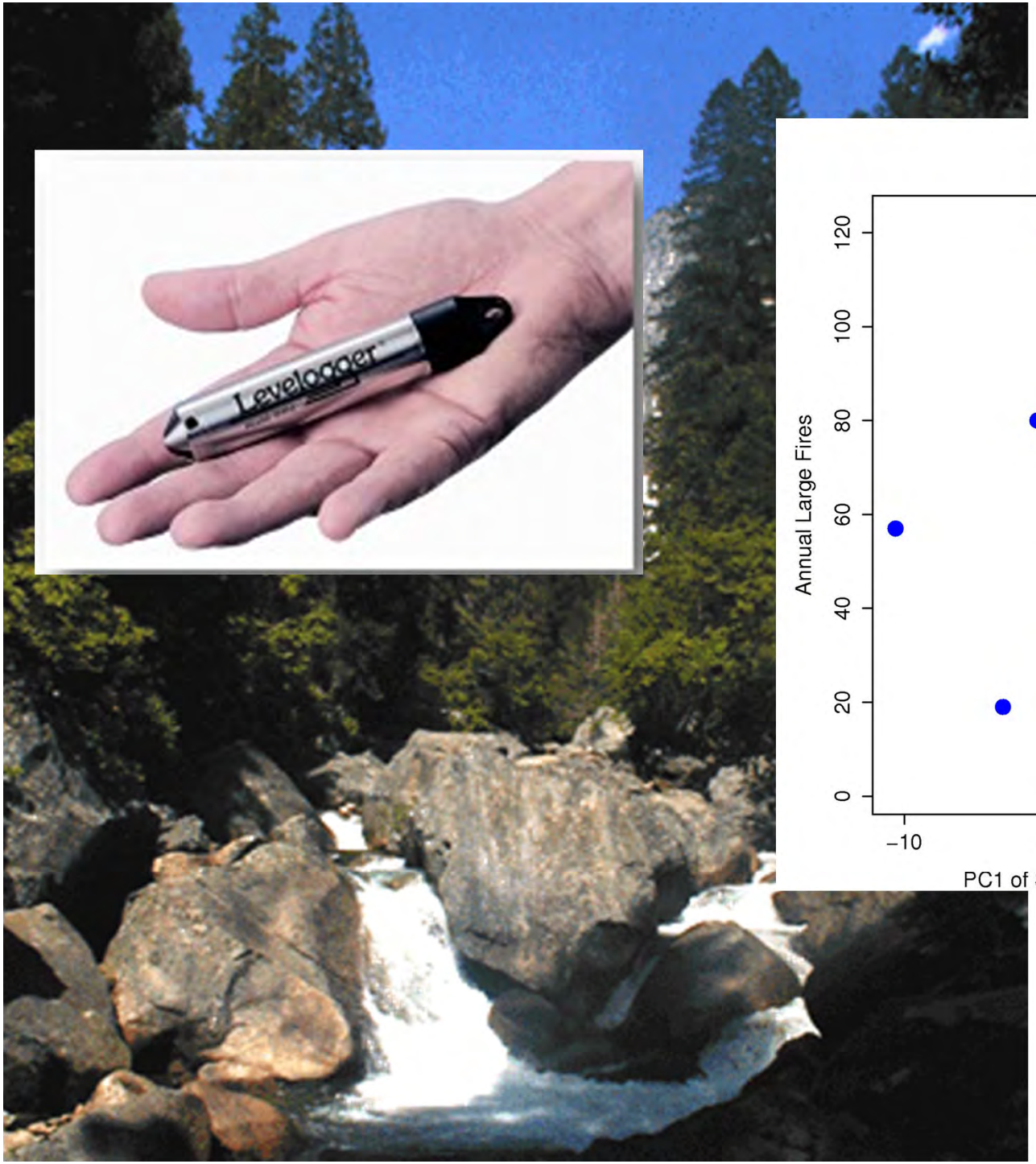




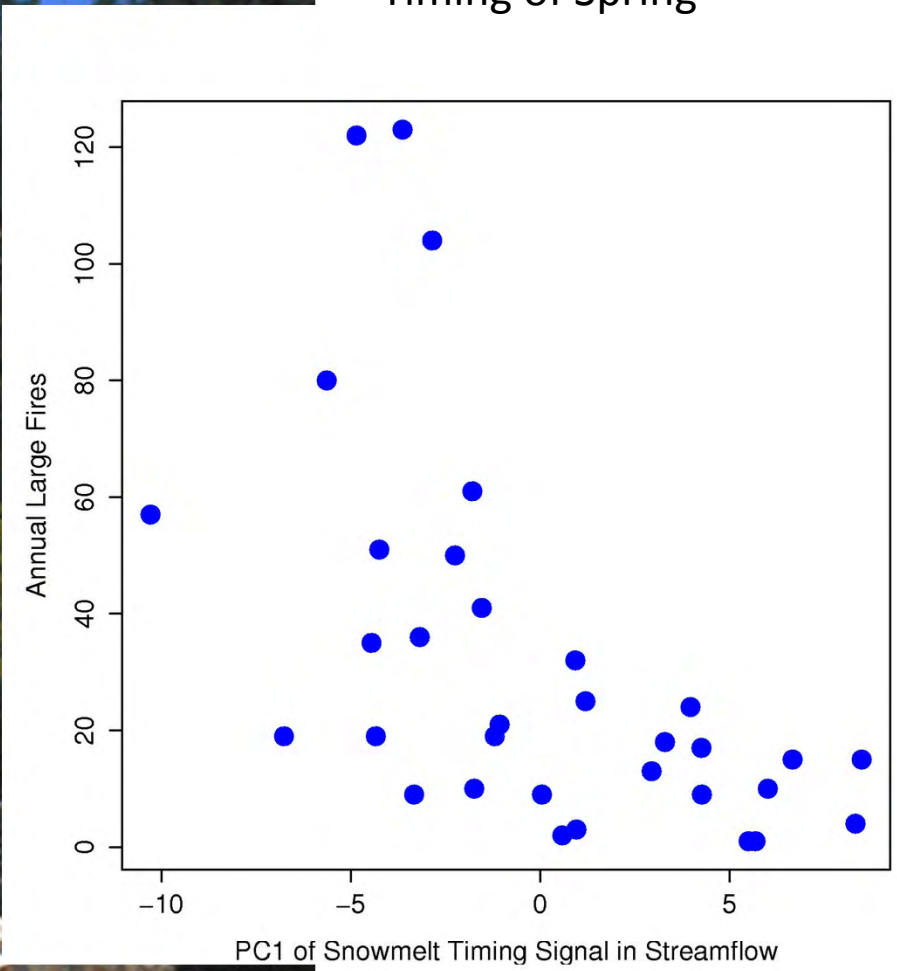

Grass/Shrub fires
follow WET years
Forests burn
when they are DRY
WET
PDSI
DRY
2
1
0
−1
−2
−4
−3
−2
−1
0
Preceding years
Year of Fire


Grass/Shrub Fires and Temperature
Fires
100
150
200
250
300
350
−0.4
−0.2
0.0
0.2
0.4
0.6
0.8
T anomaly (Deg C)
Correlation: 0.08

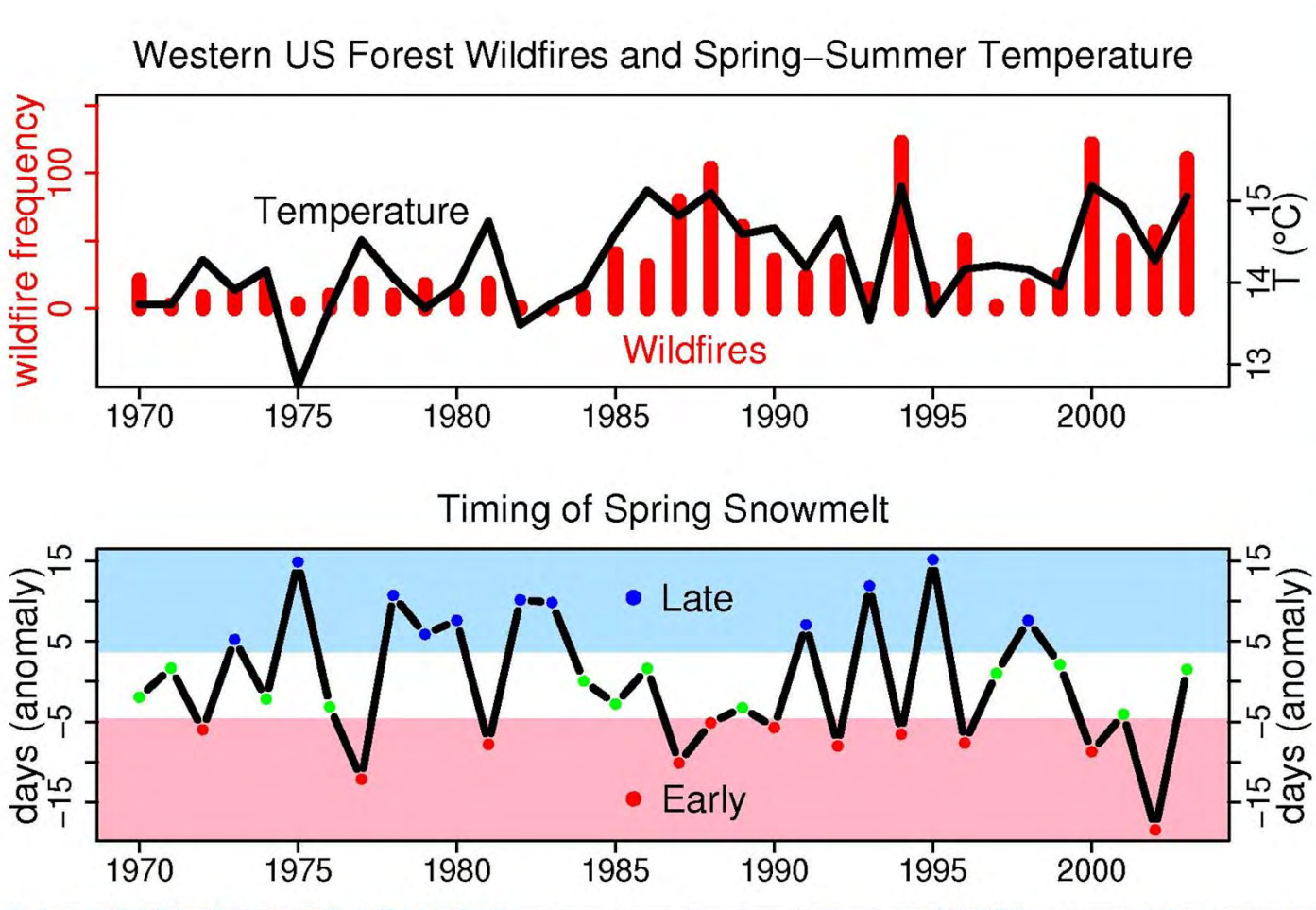

Forest Fires & Temperature
Correlation: 0.70
Fires
0
50
100
150
−0.5
0.0
0.5
T anomaly (Deg C)

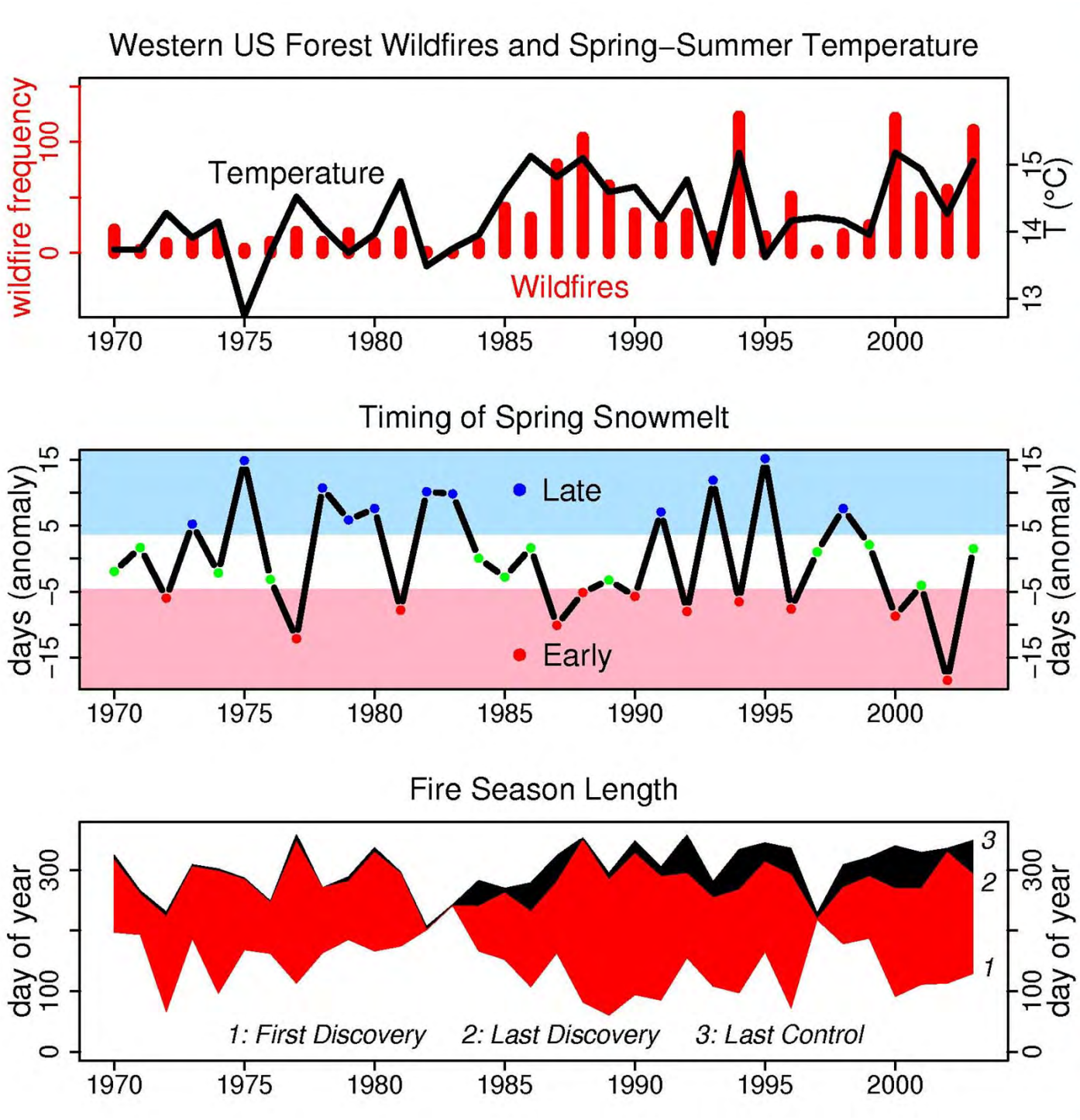


Forest Fires &
Timing of Spring

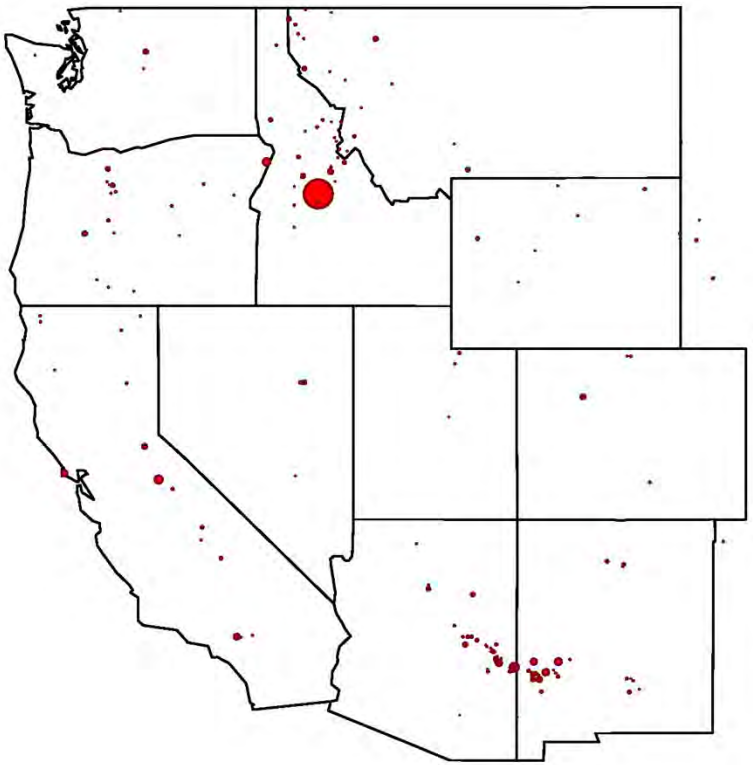


Correlation: 0.56

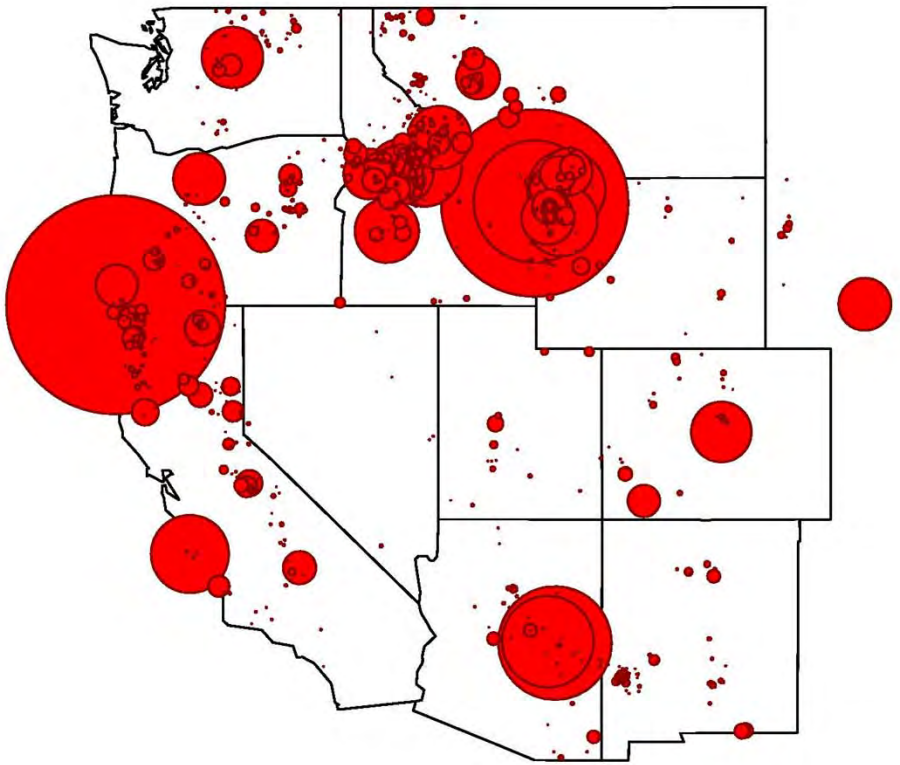

Western US Forest Wildfires and Spring–Summer Temperature
wildfire frequency
0
100
Temperature
Wildfires
13
14
15
T (°C)
1970
1975
1980
1985
1990
1995
2000
Timing of Spring Snowmelt
days (anomaly)
−15
−5
5
15
Late
Early
1970
1975
1980
1985
1990
1995
2000


Western US Forest Wildfires and Spring–Summer Temperature
wildfire frequency
0
100
Temperature
Wildfires
13
14
15
T (°C)
1970
1975
1980
1985
1990
1995
2000
Timing of Spring Snowmelt
days (anomaly)
−15
−5
5
15
Late
Early
Fire Season Length
day of year
0
100
300
1: First Discovery
2: Last Discovery
3: Last Control
1
2
3

Late Snowmelt Years



Early Snowmelt Years



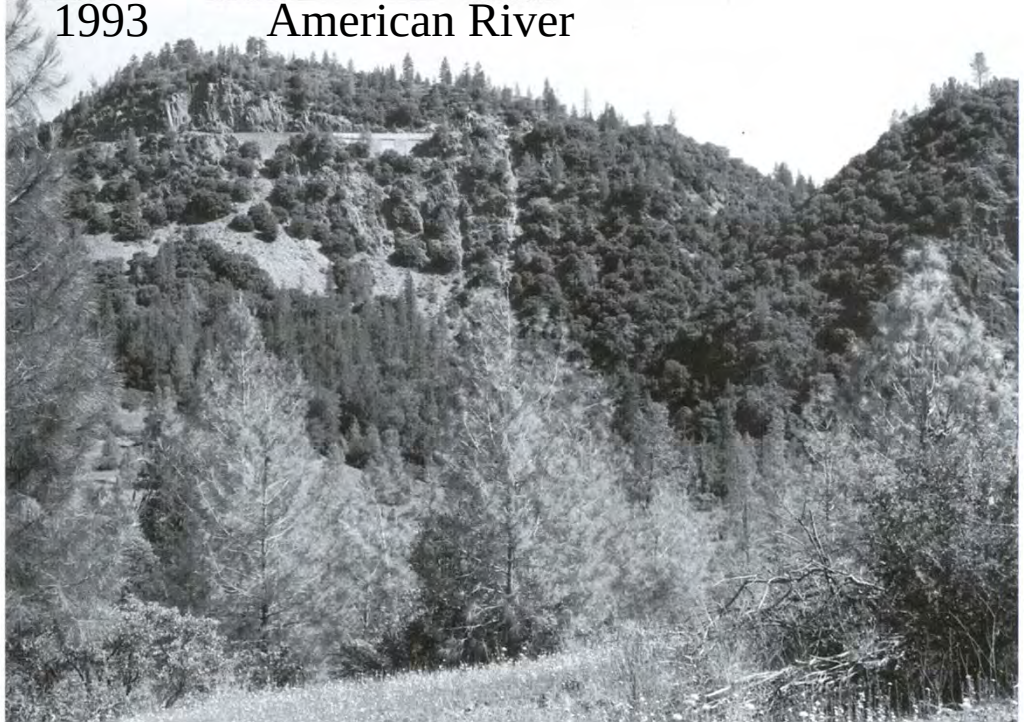
1972 - 2003, NPS, USFS & BIA Fires over 1000 acres

Understory Fire Regimes

- Fire suppression has increased amount and connectivity of fuels
  - Unnatural increase tree density
- Fire regime **has** changed
  - Fires are less frequent and more severe
  - Increased risk of severe fire

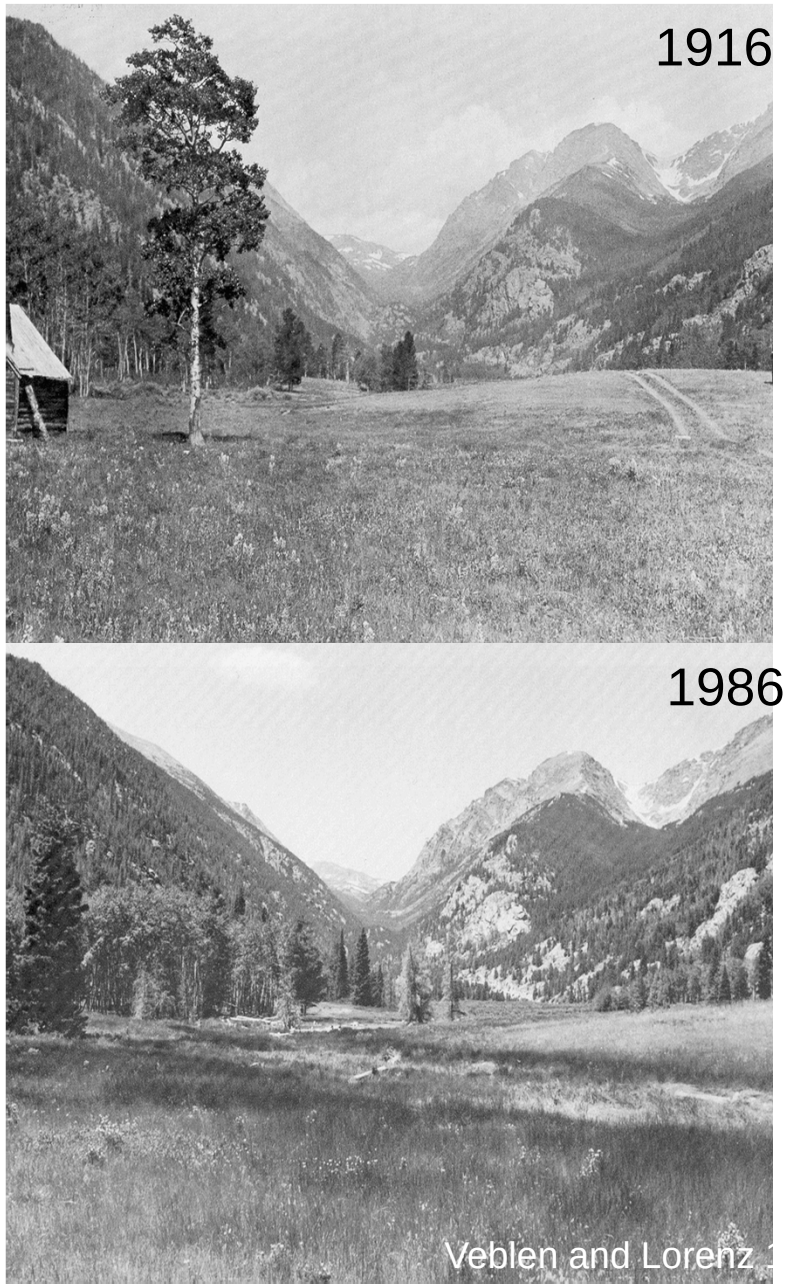
1867 American River

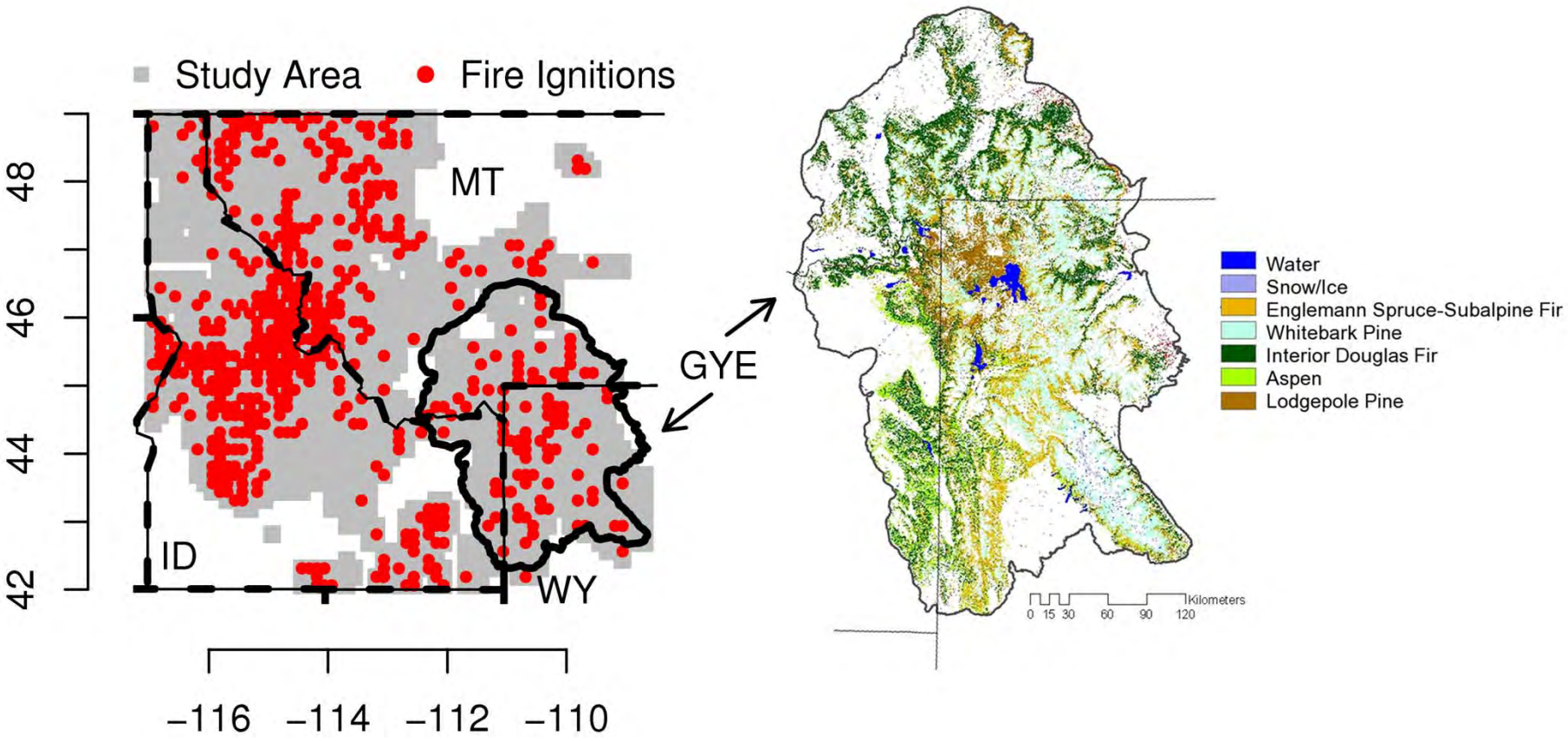
1993 American River

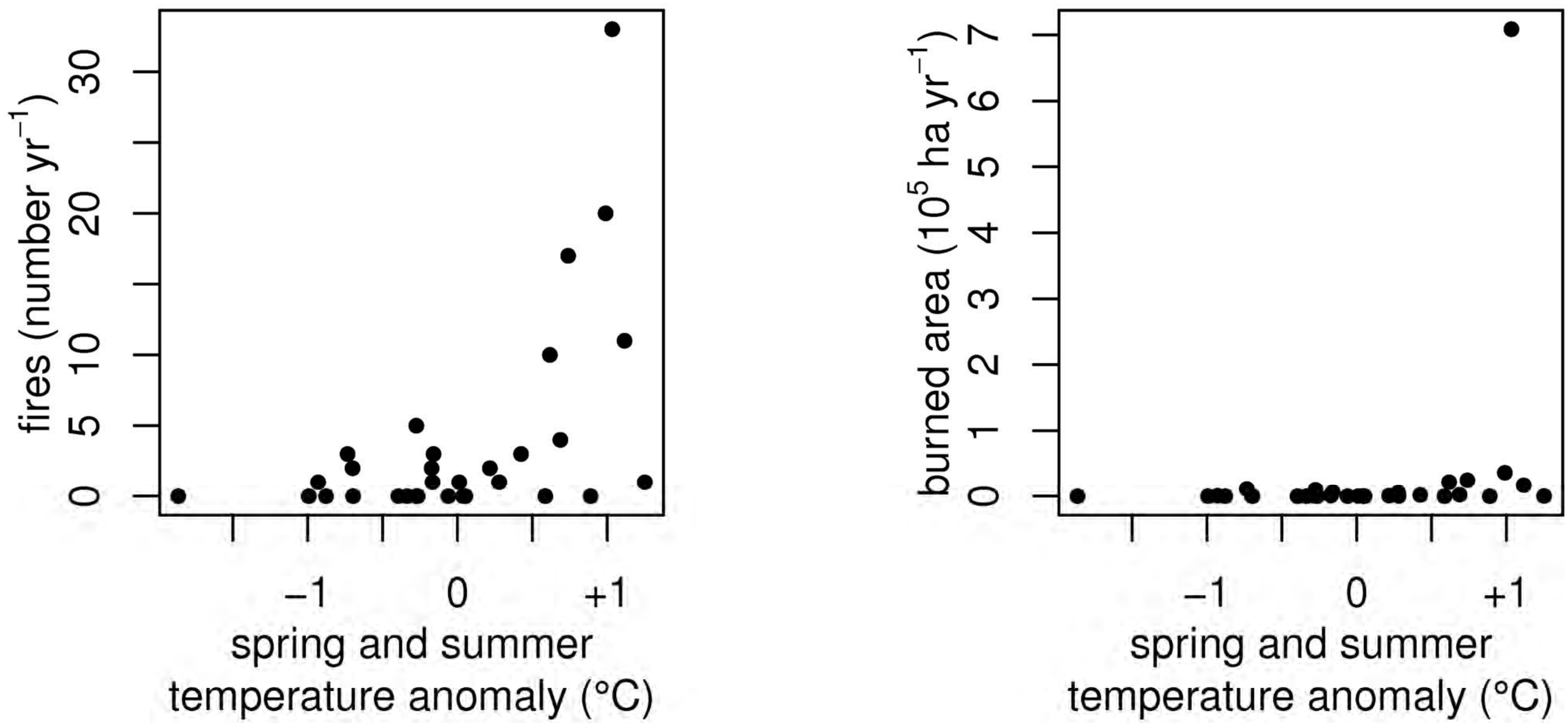


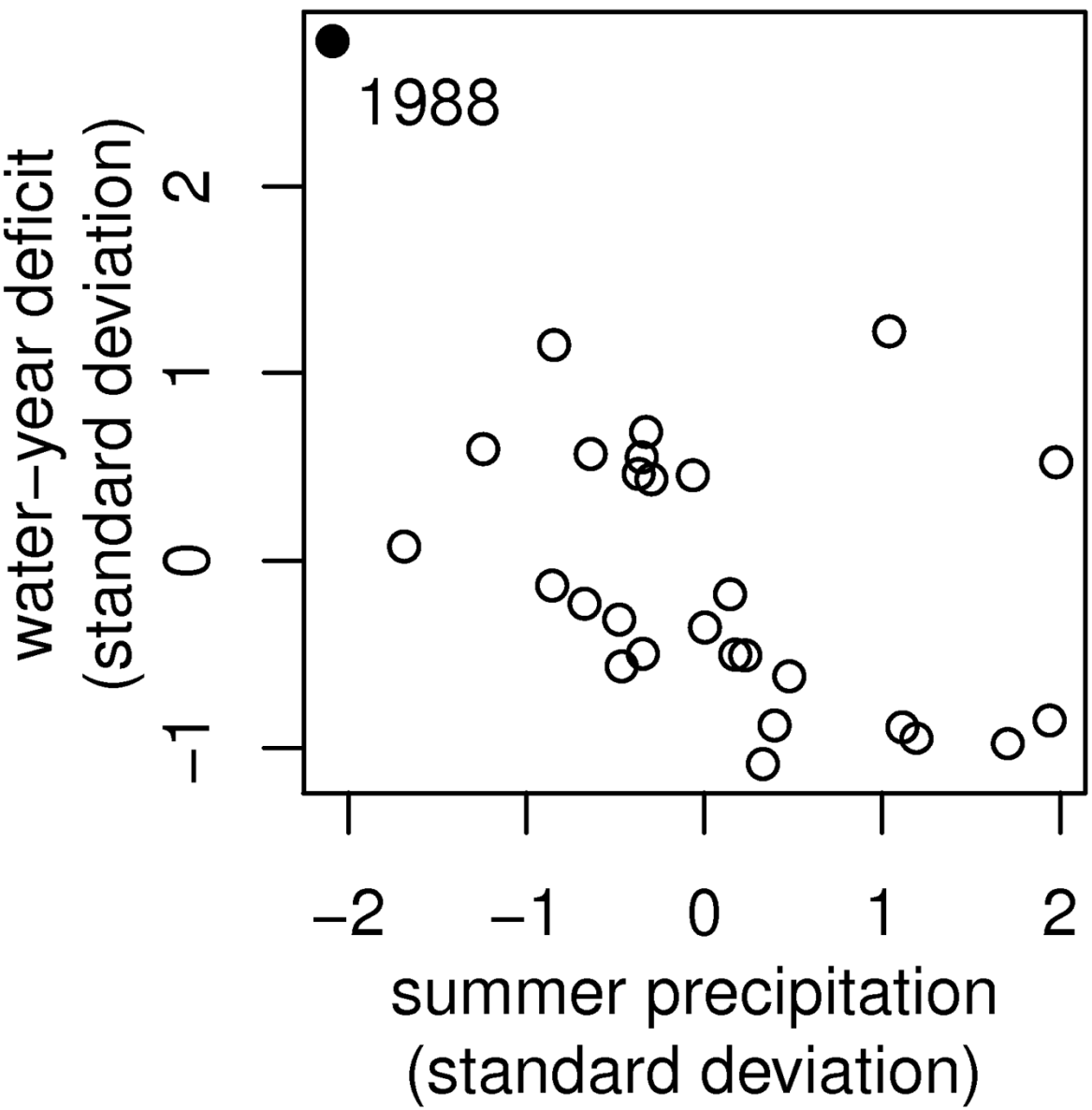
Stand-replacement Fire Regime

- Fire suppression has had little effect
  - Tree densities changed little over last century
- Fire regime has **not** changed
  - Infrequent, severe crown fires are natural and still dominate




Study Area
Fire Ignitions
MT
ID
WY
GYE
48
46
44
42
−116
−114
−112
−110
Water
Snow/Ice
Englemann Spruce-Subalpine Fir
Whitebark Pine
Interior Douglas Fir
Aspen
Lodgepole Pine
Kilometers
0 15 30 60 90 120

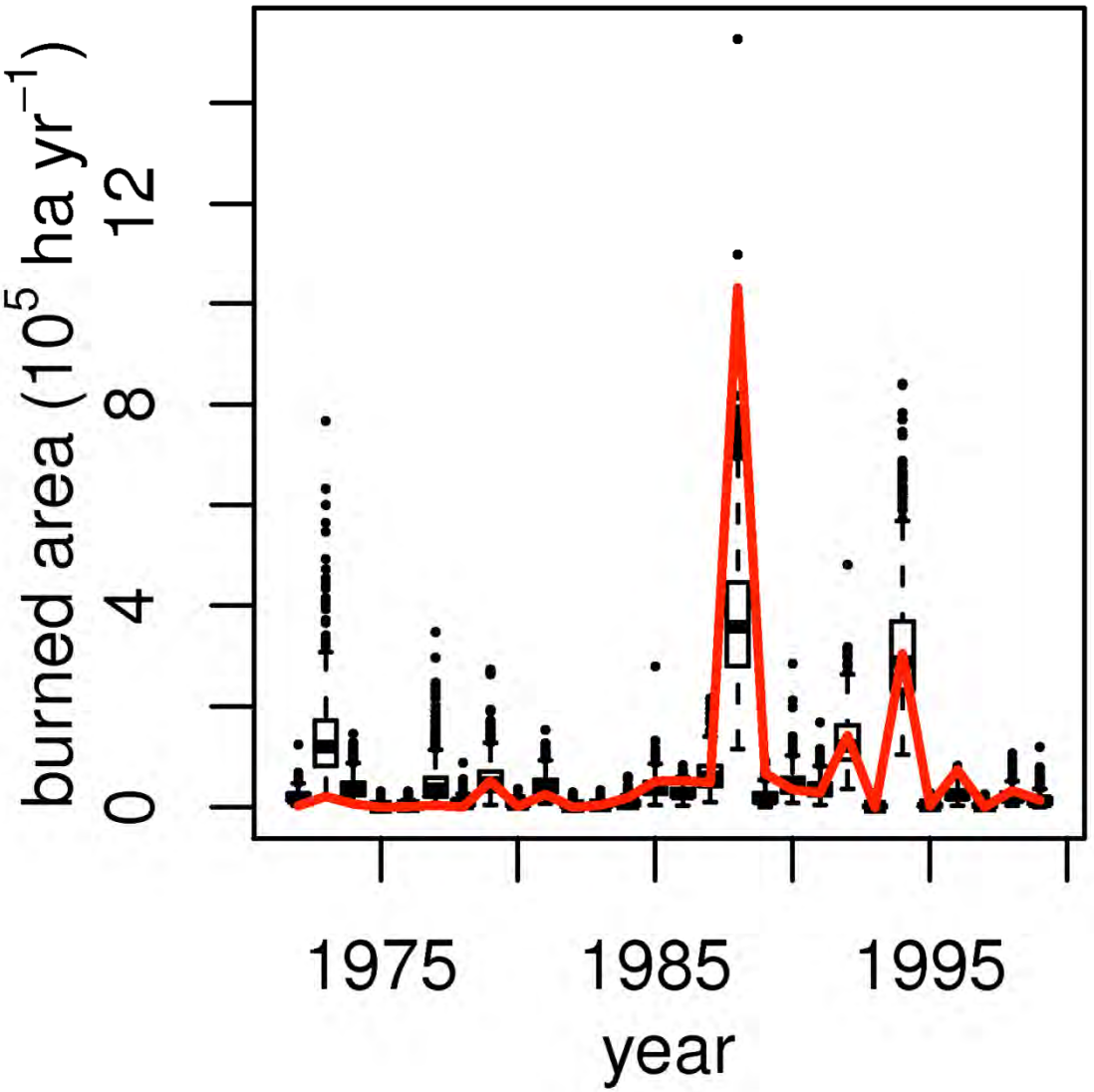

fires (number yr⁻¹)
0
5
10
20
30
–1
0
+1
spring and summer
temperature anomaly (°C)
burned area (10⁵ ha yr⁻¹)
0
1
2
3
4
5
6
7
–1
0
+1
spring and summer
temperature anomaly (°C)

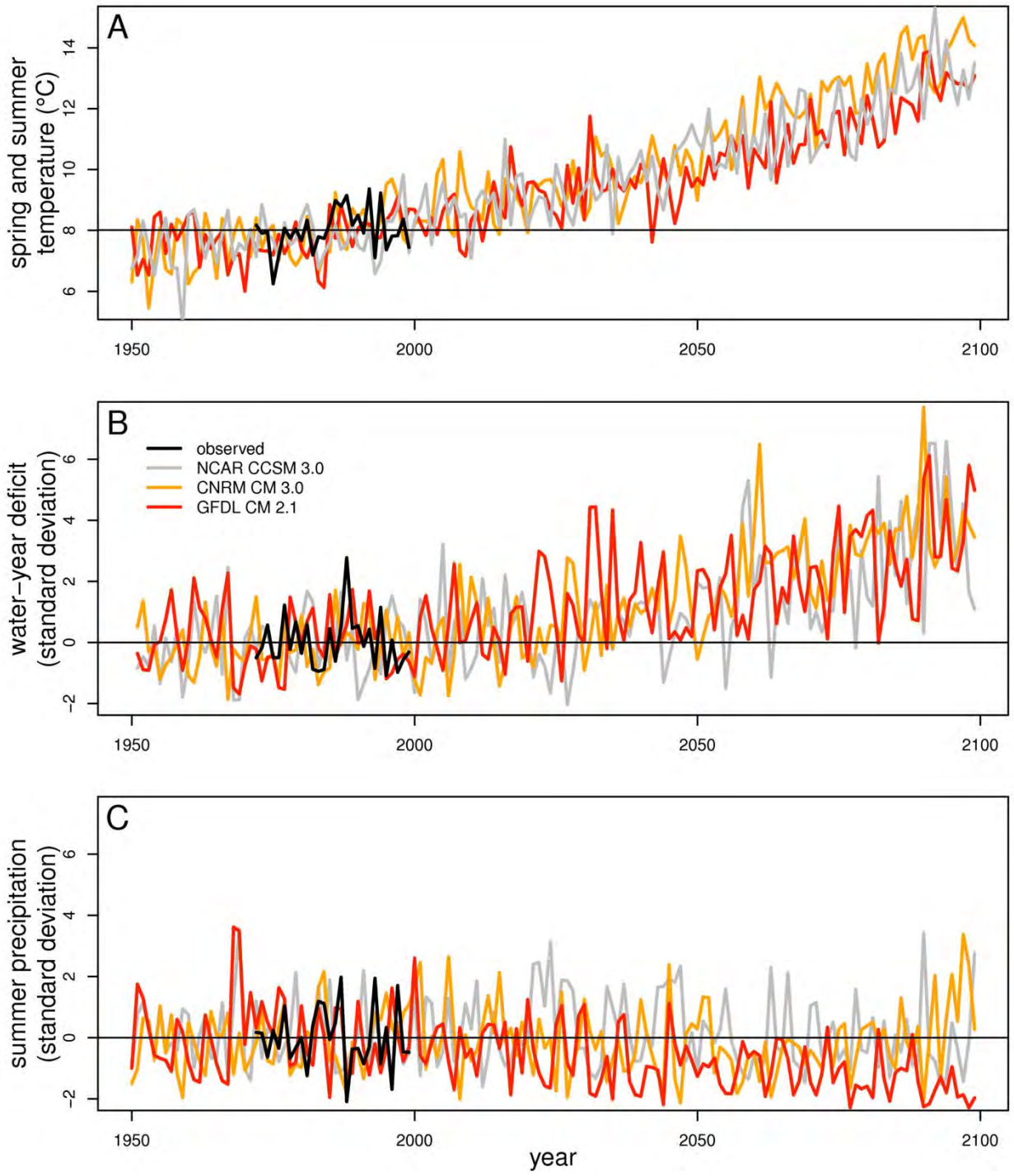

1988
water−year deficit
(standard deviation)
−1
0
1
2
−2
−1
0
1
2
summer precipitation
(standard deviation)

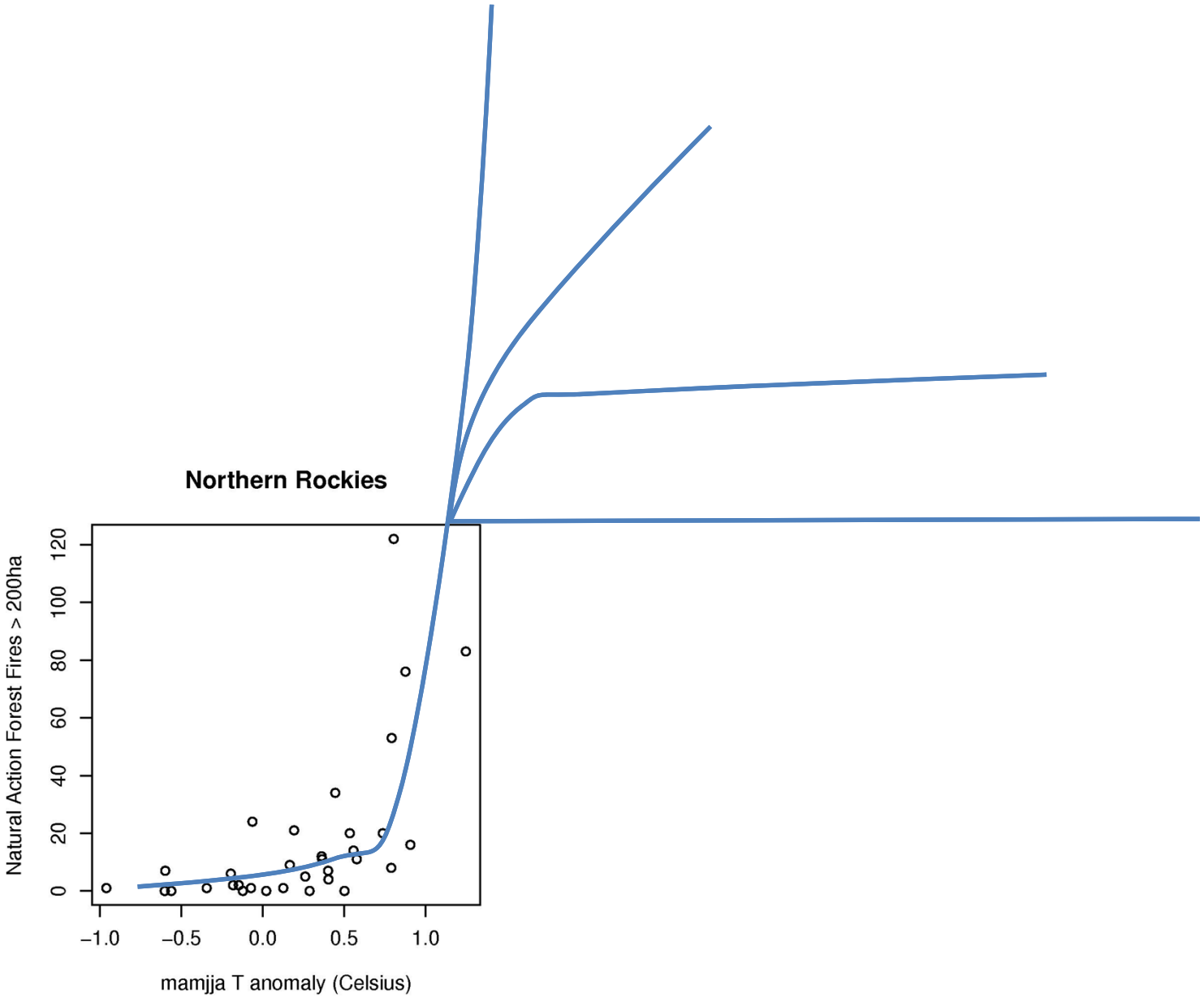
Fire Modeling

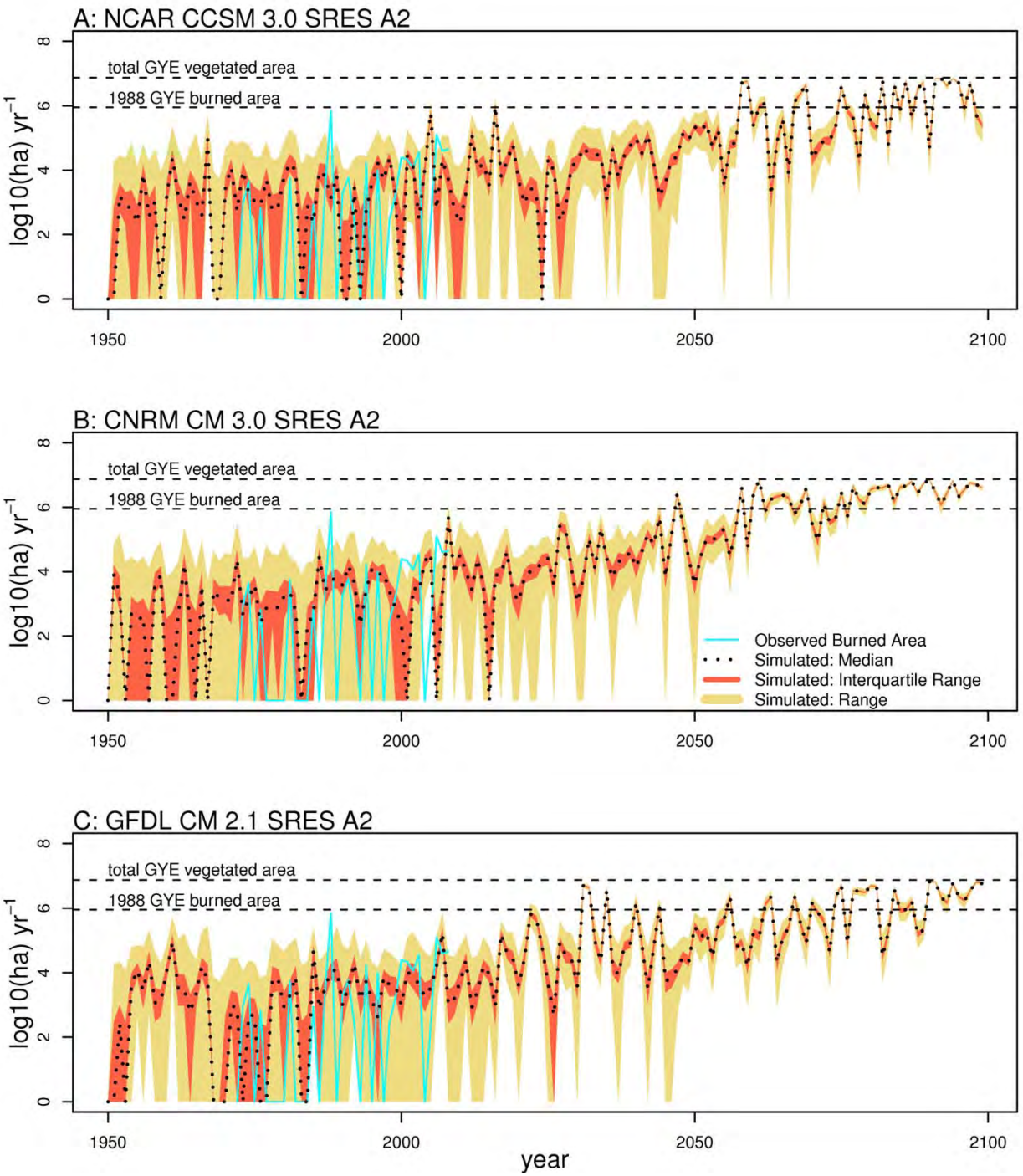
Fire Presence/Absence	Conditional Fire Number	Conditional Burned Area
Logit Model	Poisson Lognormal	Generalized Pareto
Temperature Precipitation Moisture Deficit Topography Location & Month	Temperature Precipitation Moisture Deficit Topography Location & Month	Moisture Deficit
Grid/Month	Grid/Month/Presence	Grid/Month/Fire

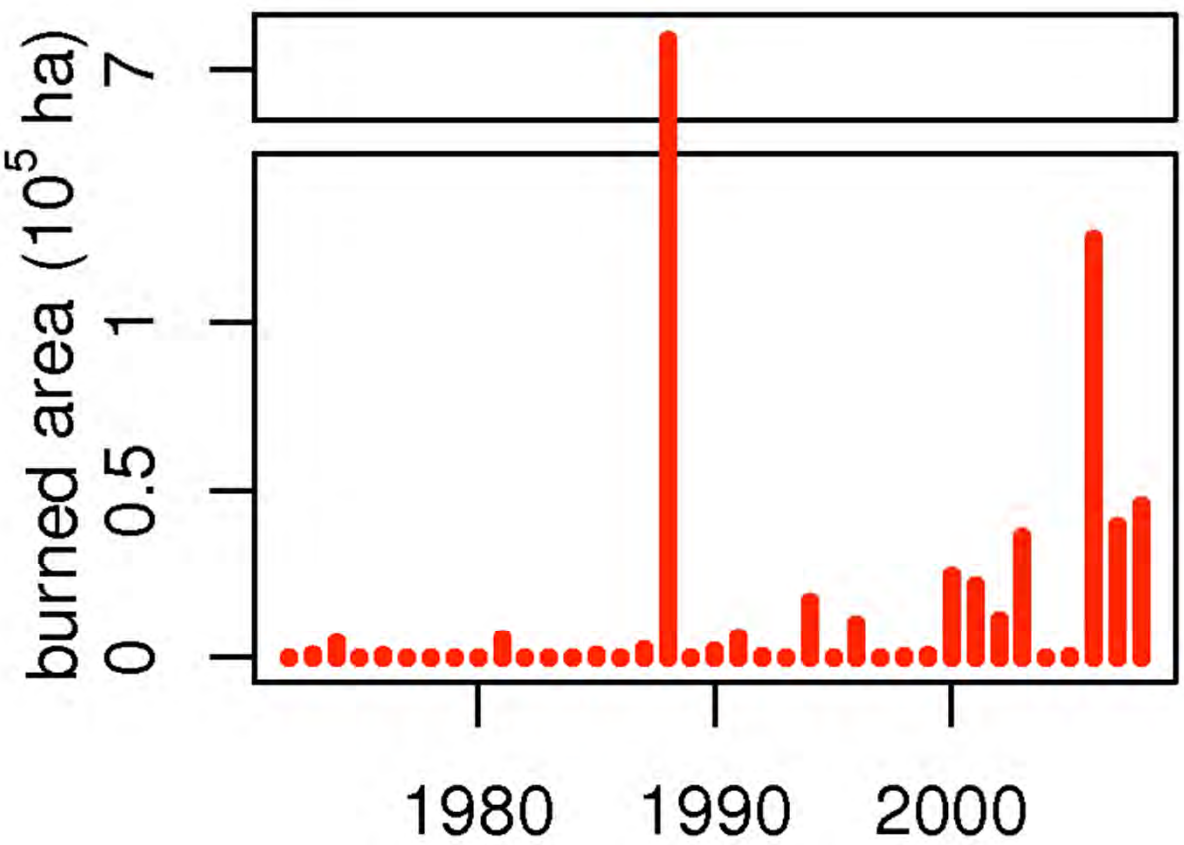
Combined models: Burned Area




A
spring and summer temperature (°C)
6
8
10
12
14
1950
2000
2050
2100
B
observed
NCAR CCSM 3.0
CNRM CM 3.0
GFDL CM 2.1
water−year deficit (standard deviation)
−2
0
2
4
6
1950
2000
2050
2100
C
summer precipitation (standard deviation)
−2
0
2
4
6
1950
2000
2050
2100
year


Northern Rockies
Natural Action Forest Fires > 200ha
0
20
40
60
80
100
120
−1.0
−0.5
0.0
0.5
1.0
mamjja T anomaly (Celsius)


A: NCAR CCSM 3.0 SRES A2
B: CNRM CM 3.0 SRES A2
C: GFDL CM 2.1 SRES A2
total GYE vegetated area
1988 GYE burned area
log10(ha) yr−1
0
2
4
6
8
1950
2000
2050
2100
year
Observed Burned Area
Simulated: Median
Simulated: Interquartile Range
Simulated: Range


burned area (10^5 ha)
0
0.5
1
7
1980
1990
2000

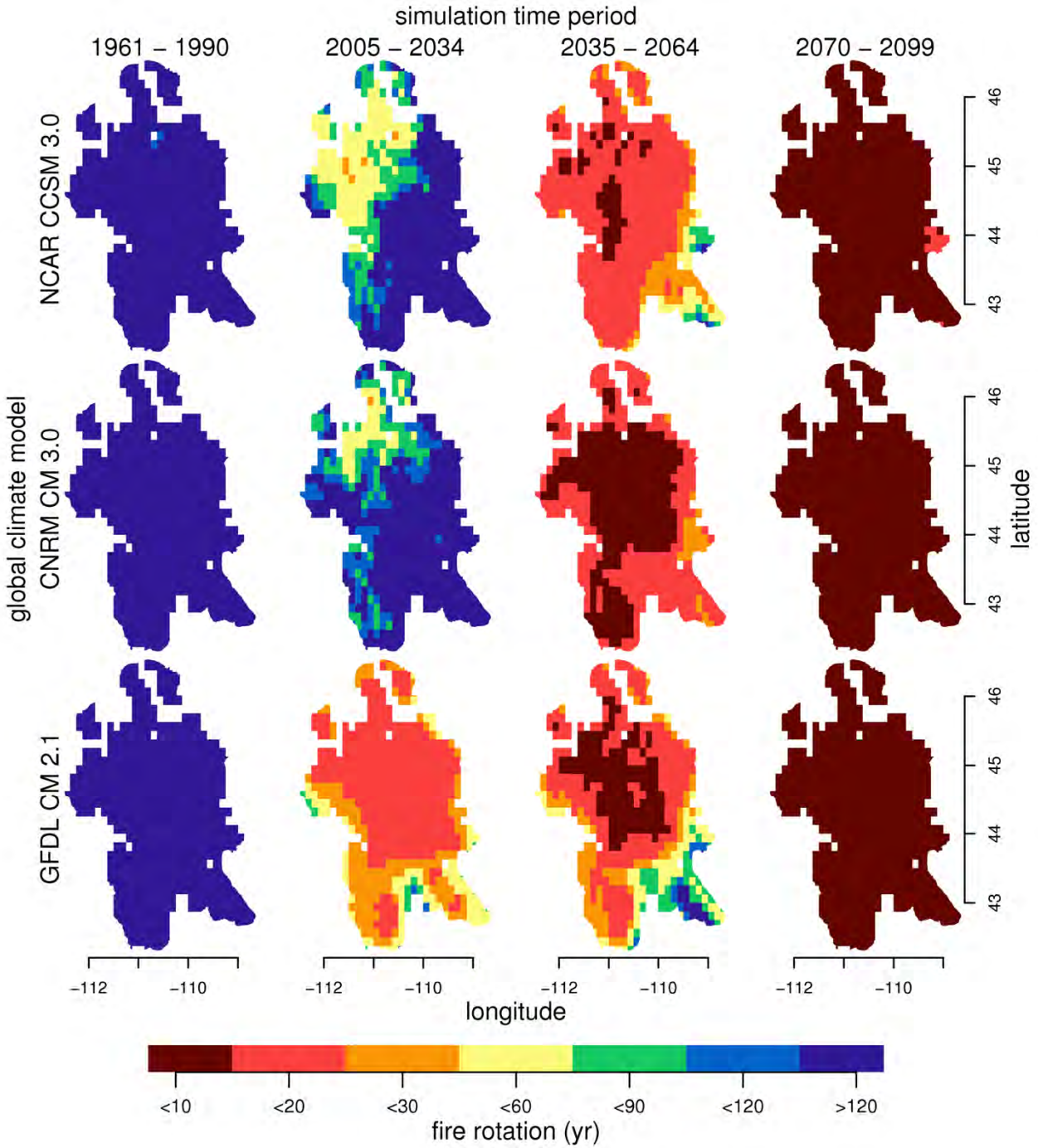
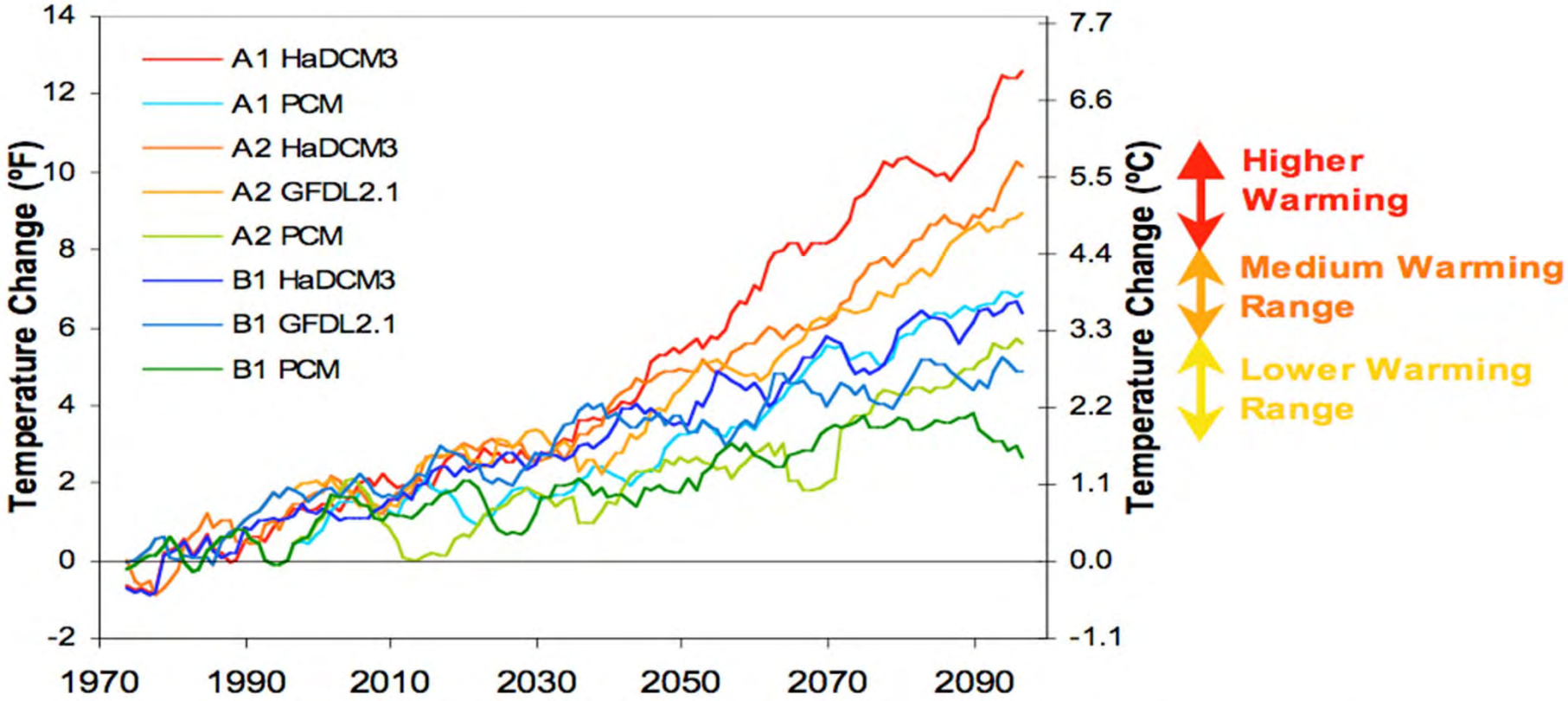

simulation time period
1961 – 1990
2005 – 2034
2035 – 2064
2070 – 2099
global climate model
NCAR CCSM 3.0
CNRM CM 3.0
GFDL CM 2.1
latitude
46
45
44
43
−112
−110
longitude
<10
<20
<30
<60
<90
<120
>120
fire rotation (yr)

Figure 4-2. Change in California Annual Average Daily Mean Temperature Relative to 1961-1990



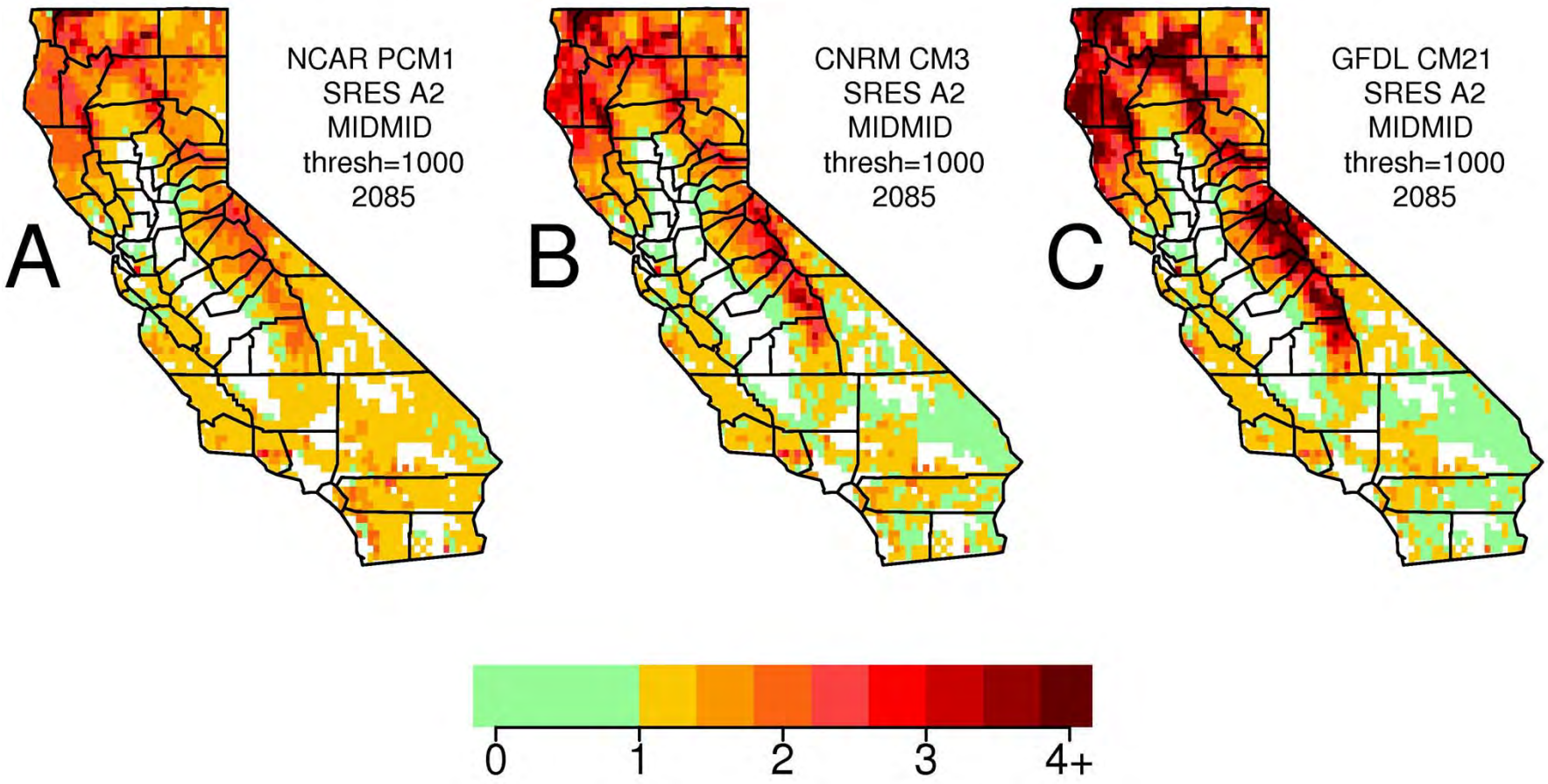
Change in California annual mean temperature (°F and °C) by year from 1961 to 2100 relative to 1961–1990 average—7-year running mean.

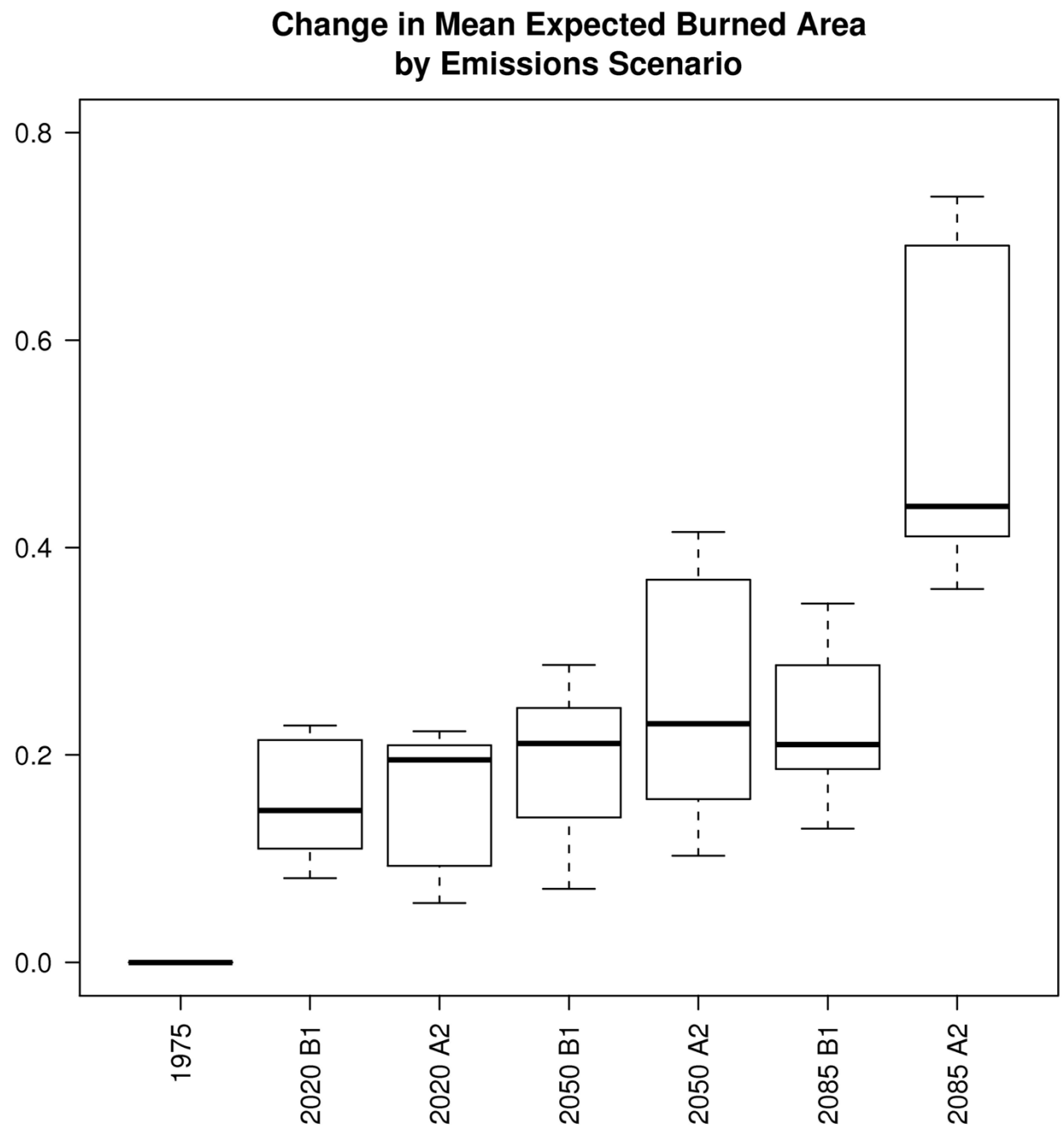
HadCM3 = Hadley Climate Model version 3

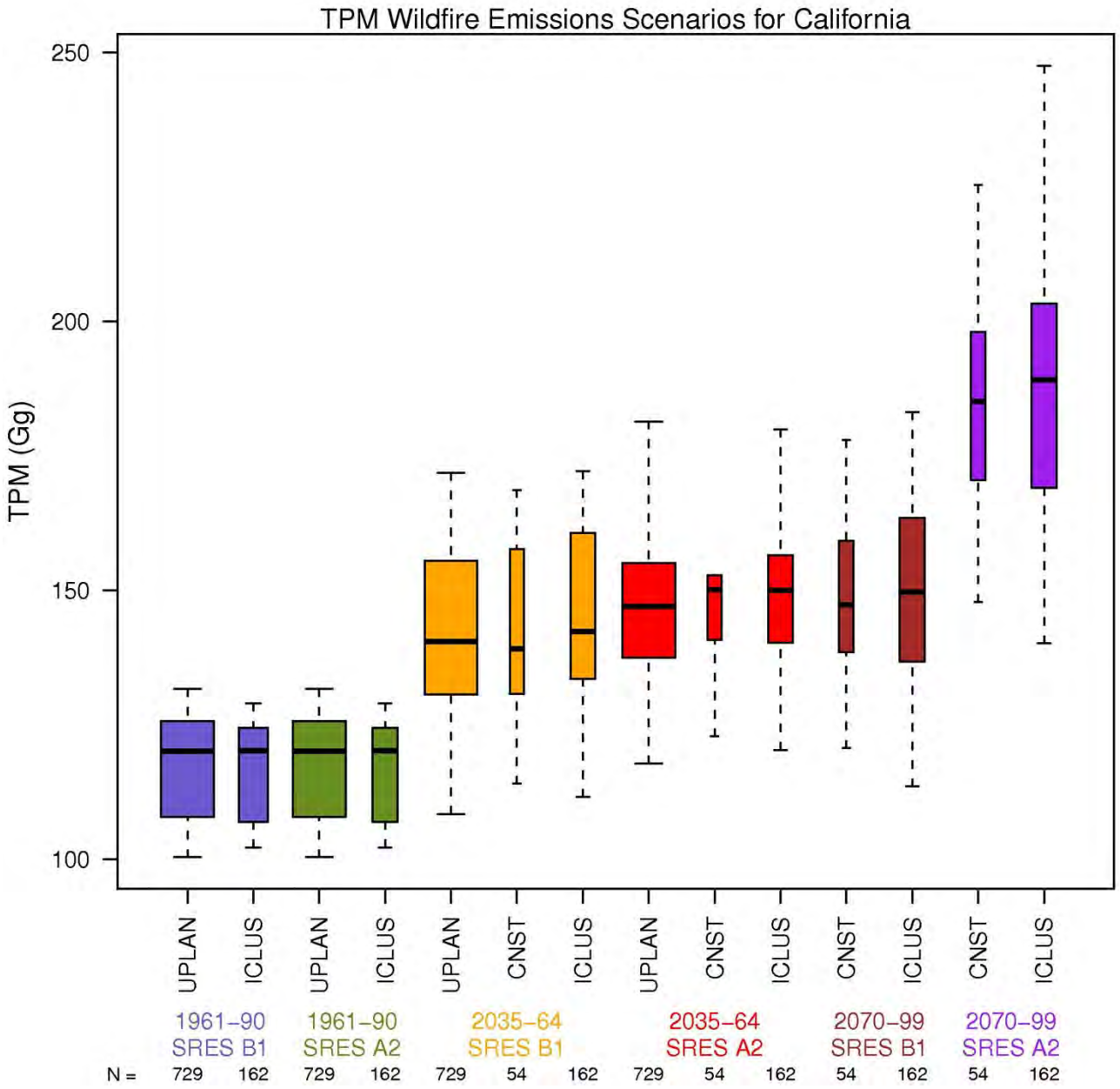
PCM = Parallel Climate Model

GFDL2.1 = Geophysical Fluid Dynamics Laboratory model 2.1

A1, A2, and B1 refer to global emission scenarios explained in Section 4. They are higher (A1), medium-high (A2), and lower (B1) emission scenarios.


A
NCAR PCM1
SRES A2
MIDMID
thresh=1000
2085
B
CNRM CM3
SRES A2
MIDMID
thresh=1000
2085
C
GFDL CM21
SRES A2
MIDMID
thresh=1000
2085
0
1
2
3
4+


Change in Mean Expected Burned Area
by Emissions Scenario
0.8
0.6
0.4
0.2
0.0
1975
2020 B1
2020 A2
2050 B1
2050 A2
2085 B1
2085 A2


TPM Wildfire Emissions Scenarios for California
TPM (Gg)
250
200
150
100
UPLAN
ICLUS
UPLAN
ICLUS
UPLAN
CNST
ICLUS
UPLAN
CNST
ICLUS
CNST
ICLUS
CNST
ICLUS
1961–90
SRES B1
1961–90
SRES A2
2035–64
SRES B1
2035–64
SRES A2
2070–99
SRES B1
2070–99
SRES A2
N =
729
162
729
162
729
54
162
729
54
162
54
162
54
162

Average annual wildfire CO2 Emissions